Automated Waste-Handling System for Layer Chicken Hatcheries

ARS-S-186

October 1978

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

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ILLUSTRATIONS

Automated Waste-Handling System for Layer Chicken Hatcheries

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ABSTRACT

Major equipment components, consisting essentially of a receiving tank for separating the waste product from the airstream and for temporarily storing waste; a vacuum pump and motor; two hoppers for collecting and feeding cockerels and other waste products into a transport tube; an automatic tray dumper; a pneumatic ram for moving trays from the sexing line onto the automatic tray dumper; and accessory motors, pipes, and conveyors, were developed and tested in an effort to further update and automate the handling of hatchery waste in layer facilities and to reduce the manual-labor requirements for these operations. This waste-handling system was tested for 7 months in a commercial layer hatchery (hatched 125,000 eggs per day) with no major problems. The system is commercially feasible and practical. It reduces labor requirements by more than 50 percent and makes cleaning up easier. Adoption of the complete system by industry could significantly reduce the cost of waste handling in layer hatcheries.
KEYWORDS: chicken hatcheries, waste disposal, waste-disposal systems (automated).

INTRODUCTION

In past years, improvements in equipment for the hatchery industry were involved with the handling of eggs before they hatched, and improved incubators and new storage techniques were adopted primarily to increase the hatchability of the eggs. However, very little attention was given to eliminating the problems of handling the waste product after the eggs hatch. Our earlier work on handling hatchery waste was concerned with the development of a pneumatic system for transporting the waste material out of a small broiler hatchery and into a temporary holding tank (Agricultural Research Service Report ARS–S–152, "A Vacuum System for Handling Chicken Hatchery Waste"). This waste consisted primarily of eggshells and unhatched eggs. A layer chicken hatchery has different requirements, and the difference between broiler and layer hatcheries usually begins where the chicks are sexed. In the layer hatchery, the facilities must provide for disposing of the cockerels (about one-half of the chicks) as well as the waste from the tray (shells, dead embryos, and unhatched eggs). The addition of cockerels to the waste adds considerably more protein value to the product, and rendering plants usually accept it more readily than that from broiler hatcheries.

The purpose of this research and development work was to further update and automate the handling of hatchery waste in layer facilities and to reduce the manual-labor requirements for those unpleasant and unhealthy operations. This publication reports the results of work completed in a layer chicken hatchery and is a sequel to Report ARS–S–152.

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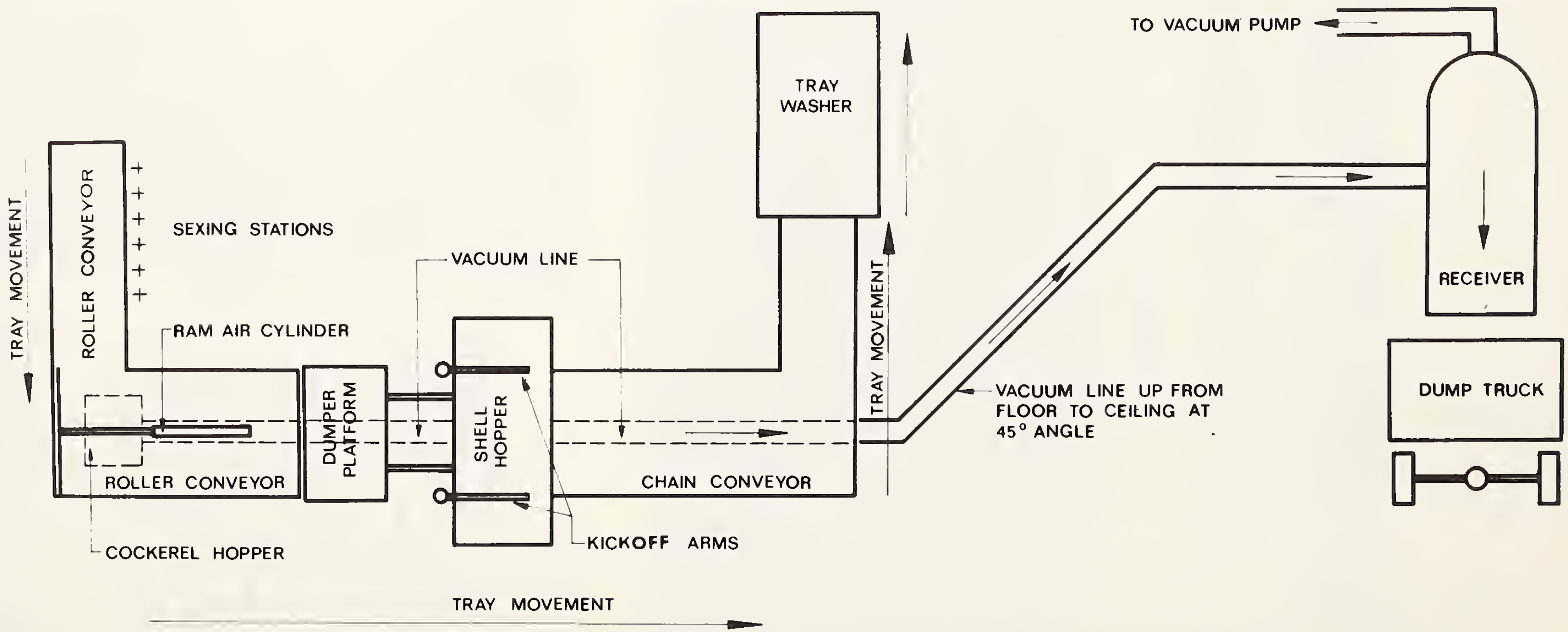

FIGURE 1.—Layout of automated waste-handling system, showing each major component.

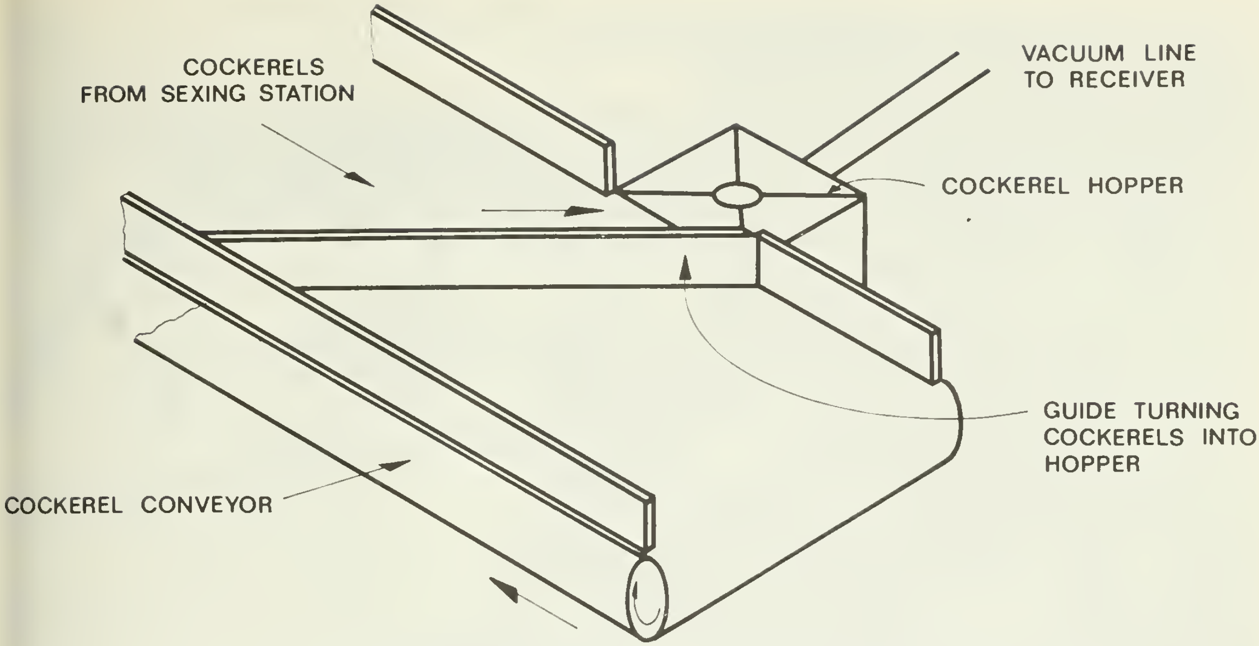

FIGURE 2.—Cockerel conveyor with guide to force cockerels into hopper for removal from hatchery area.

The cooperating hatchery in which this work was accomplished had a daily capacity of 125,000 eggs, which yielded about 55,000 pullets. The waste consisted of eggshells, unhatched eggs, dead embryos, and about 55,000 cockerels. This operation generated a total of about 12,000 pounds of waste per day, or 1,700 pounds per hour. All waste was manually dumped and collected in 55-gallon barrels, which were eventually emptied into an open-bed dump truck for transport to a rendering plant. The empty chick trays were manually fed into the tray washer. These operations were unpleasant and required four full-time workers.

EXPERIMENTAL LAYOUT AND EQUIPMENT

The major equipment components (fig. 1) developed and used in this study are a receiving tank for separating the waste product from the airstream and for temporarily storing the waste product; a vacuum pump and motor; a receiving hopper for feeding the cockerels into the transport tube; a shell hopper for receiving and feeding waste into the transport tube; an automatic tray dumper; accessory motors, pipes, and conveyors for operating the system and automatically feeding empty trays into washers; and a pneumatic ram for moving trays down perpendicularly from the sexing line onto the automatic tray dumper.

Receiver.—The receiver used at this plant was also used in the earlier study and is described in ARS–S–152. The tank has to be dumped about once each hour but works very satisfactorily. It is a butane tank, 30 inches in diameter, with a hinged door rigged on the bottom end for dumping the contents. For operations as large as the one in this study, a larger tank, approximately 500 to 600 gallons in capacity with a trap door of the same type, should be used.

Vacuum pump.—A large 400-cubic-foot-per-minute vacuum pump, powered by a 30-horsepower electric motor, is used because of the volume of waste to be handled and because there is more than one pickup station. A 3-inch PVC (polyvinyl chloride) tube is adequate for air transportation of waste. Metal sweep elbows are used because abrasive eggshells wear through PVC elbows rapidly. It would be best to use metal tubes throughout the system for product transport; however, PVC tubing is adequate for connecting the vacuum pump to the receiver.

Cockerel hopper.—This hopper (figs. 2 and 3) is used to collect and feed cockerels into the transport tube as they are dropped off the sexing conveyors. The hopper is 10 inches square and 4 inches deep and tapers to a 2½-inch opening that connects di-

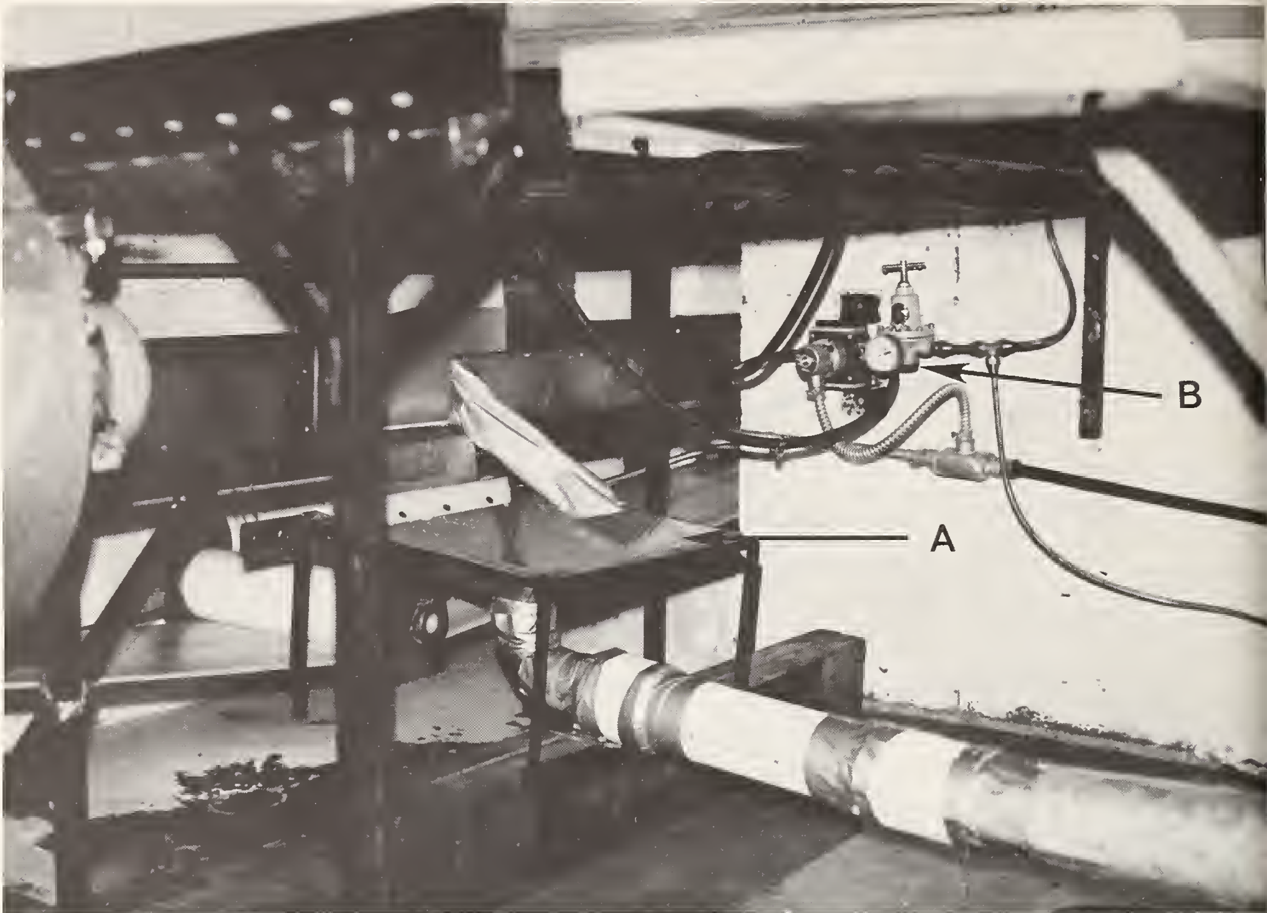

FIGURE 3.—Area beneath tray conveyor from sexing stations. A, Cockerel hopper. B, Two-position, five-port, spring-return solenoid valve to ram.

rectly to the end of the 3-inch transport tube. A diagonal guide is positioned across the sexing belt, which forces the chicks to the side and into the hopper. A high-velocity airstream moving into the transport tube pulls the chicks through the tube on a continuous basis.

Shell hopper.—The shell hopper (fig. 4, item 1) is designed to receive the waste as a tray is automatically flipped upside down over it. Modifications in the hopper aid in the positioning, dumping, and discharging of trays to keep waste product off the floor. These consist of 4-inch-high side pieces (5) to guide trays and a 10-inch extension on one side of the hopper. The hopper is fastened to a 10-inch rotary airlock valve (2) for feeding the waste into the transport tube. Eggshells do not feed from a narrow hopper bottom without some agitation because they bridge across the opening and jam. The airlock valve serves as an agitator and feeds the waste product into the airstream in the tube at a constant prescribed rate, thus minimizing air leakage at this pickup station.

Automatic tray dumper.—The tray dumper is designed and built to work in conjunction with the hopper and airlock valve (fig. 4, items 1 and 2). The dumper has a pneumatic cylinder (6) which carries a platform through a 100° arc, tilting the tray to a point where it will fall off upside down onto the hopper and deposit the waste into the hopper. Stainless-steel rods across the top of the hopper and extending beyond it keep the trays from falling into the hopper and allow the trays to be moved off the hopper for removal to the washer by a chain conveyor. The major components of the dumper are the lift platform, cam-operated air switch, and two kickoff arms.

The lift platform (16) is a spring-loaded, pneumatically controlled table on which the tray sits for dumping. The platform table is slightly wider than a tray, with tapered uprights as guides so the tray

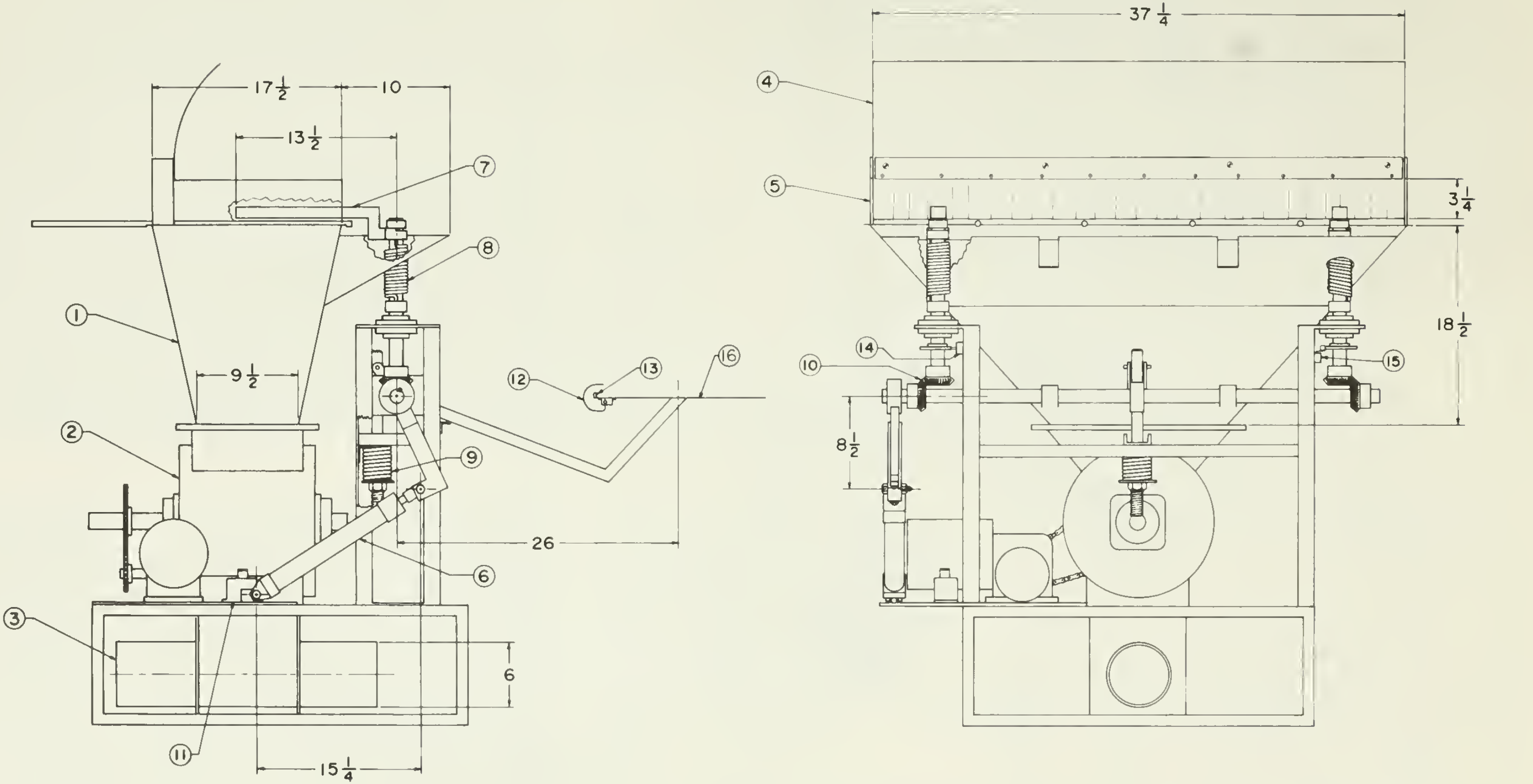

FIGURE 4.—Plans for shell hopper and automatic dumper. 1, Galvanized sheet-metal shell hopper. 2, Ten-inch rotary airlock valve. 3, Six-inch steel transition. 4, Striker plate. 5, Four-inch guide rails. 6, Double-acting air cylinder with 1½-inch bore. 7, Kickoff arms. 8, Torsion springs. 9, Compression spring. 10, Bevel gears. 11, Two-position, five-port, spring-return solenoid valve. 12, Lift-platform (tray-table) limit switch (LS 2). 13, One-half-inch stainless-steel stops. 14, Cam-operated air switch (LS 4). 15, Momentary-contact, spring-return, cam-actuated limit switch (LS 3). 16, Lift platform. Dimensions are in inches.

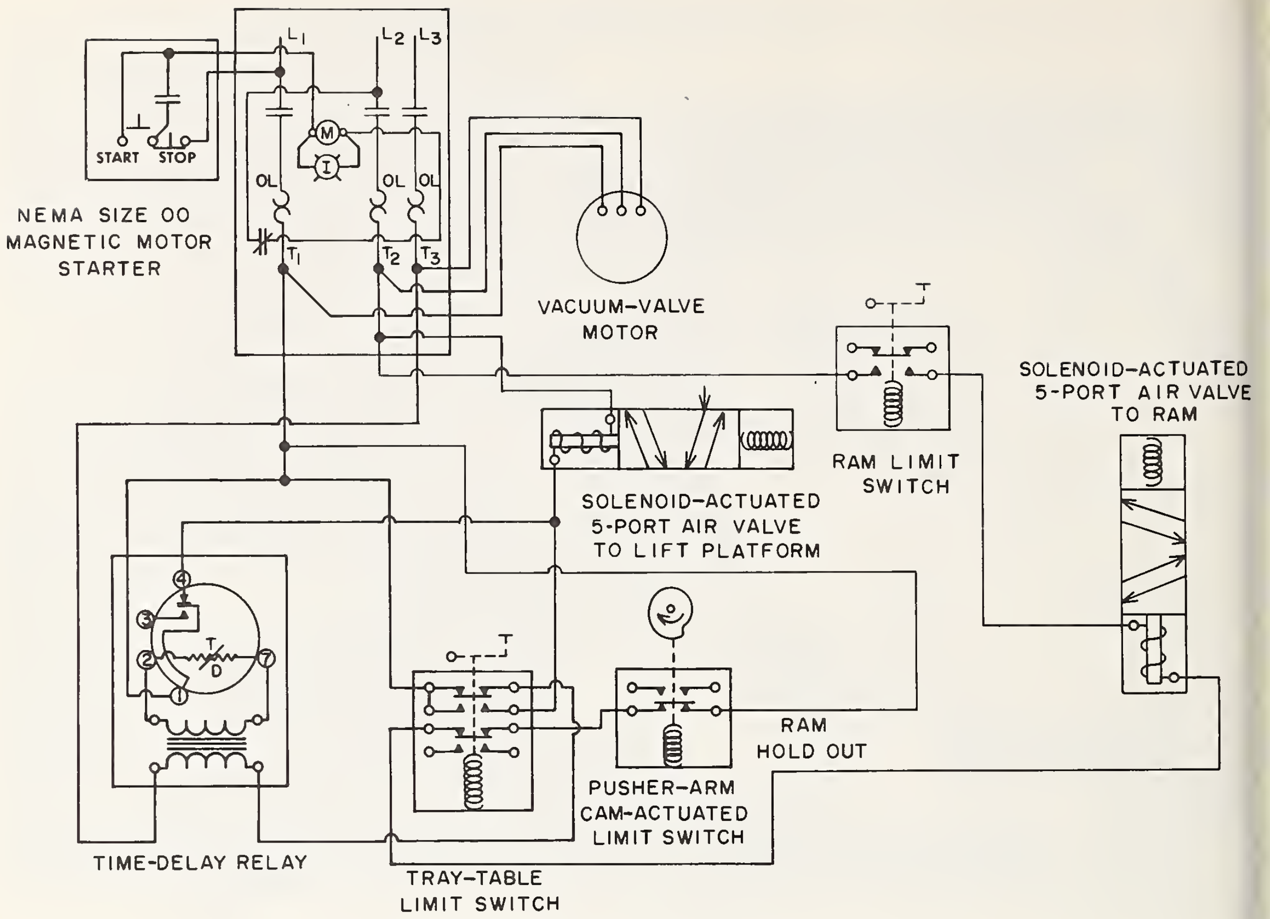

FIGURE 5.—Wiring diagram for complete dumping operation.

will be centered over the hopper when dumped. The platform is raised and lowered by a commercial 12-inch-long, double-acting pneumatic cylinder (6). To assist the air cylinder in starting the load upward, an adjustable compression spring (9) is so situated that it develops enough thrust to override the weight of a loaded tray, thus requiring less air pressure. The lift platform is hinged on a 1¼-inch shaft supported on both ends by flange-mounted pillow blocks. The complete assembly is fabricated out of angle iron and square tubing except for the platform itself, which is made from 16-gage sheet steel. All necessary bracing is also made of lightweight angle iron. The platform has two stainless-steel stops (13) on the inner side to help position the tray and keep it from sliding off. Situated between the stops is the lift-platform (tray-table) limit switch (LS 2), with two sets of normally closed (NC) contacts and one set of normally open (NO) contacts that sense the presence or absence of a tray (fig. 4, item 12; and fig. 5). The NO contacts sense the presence of the tray and actuate the air cylinder to lift the platform. One set of NC contacts is utilized in conjunction with a time-delay relay (fig. 5) to hold the platform at maximum ascent for 1½ seconds, while the other set of NC contacts disables the tray-loading mechanism so that another tray cannot be moved until the platform is ready to accept it.

Since the lift platform is moved swiftly through an arc of 100°, it is necessary to have some kind of air switch to reduce the air pressure on the last 30° to 40° of the arc and thus keep the tray from being thrown into the striker plate (fig. 4, item 4) with excessive force. This is accomplished by a cam-actuated air switch (LS 4) that reduces the pressure on the air cylinder through the last portion of the arc (fig. 4, item 14; and fig. 6). This switch bypasses the airflow control valve in the "extend" exhaust port of the spring-return solenoid valve (fig. 4, item 11).

After the tray falls upside down onto the hopper it must be removed before the next tray can be dumped. Two kickoff arms (fig. 4, item 7; and fig. 7)

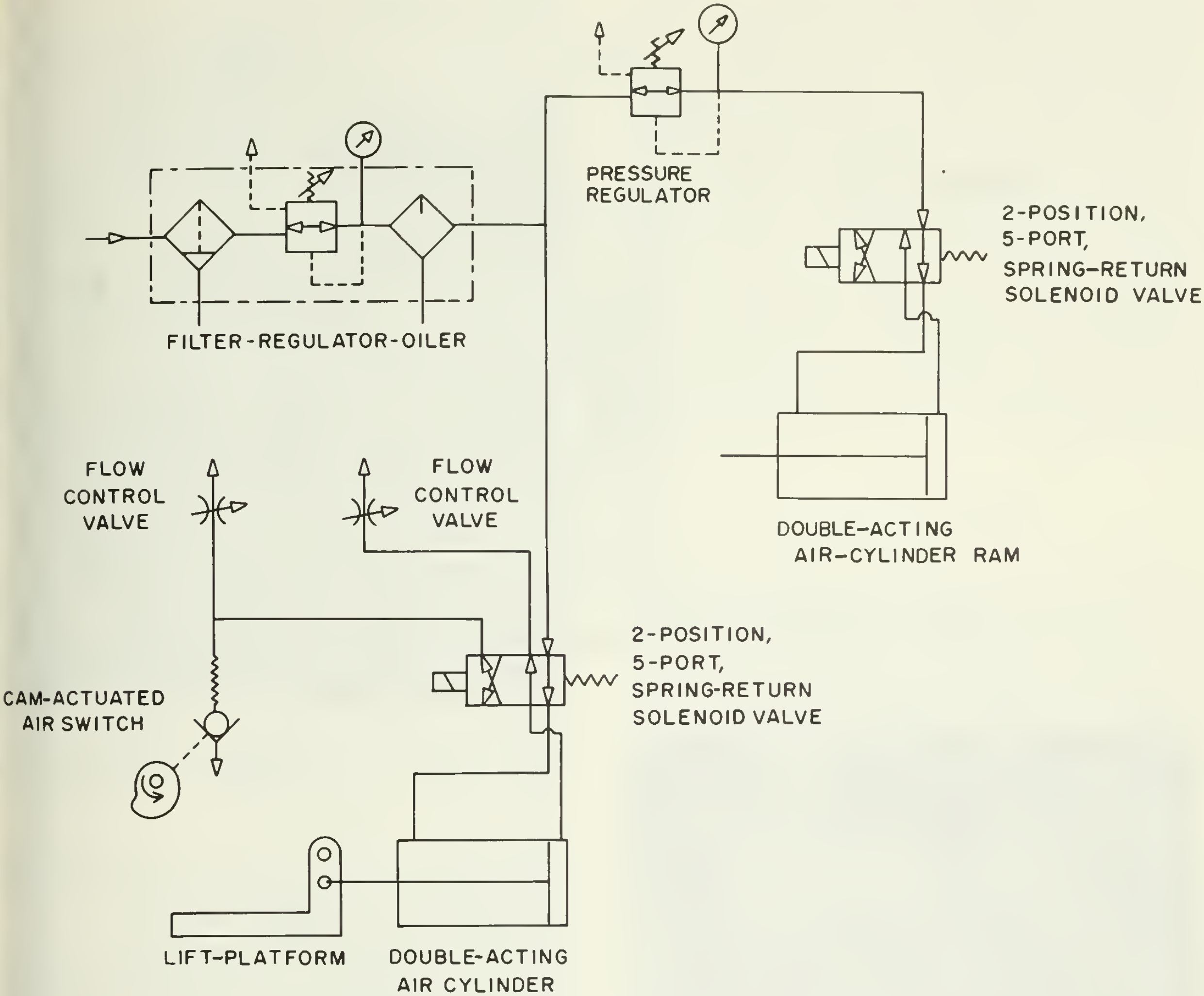

FIGURE 6.—Pneumatic diagram for complete dumping operation.

automatically push the tray off the hopper onto the washer conveyor. The arms are moved by the downward movement of the lift platform through shafts connected by bevel gears (fig. 4, item 10) to the hinge shaft of the platform. Because this is a direct-drive mechanism, something is needed to prevent damage to the tray if it becomes lodged. Normally, torsion springs (8), put over the kickoff-arm shafts that turn the kickoff arms, produce enough force to slide the tray off the hopper. The top and bottom of the spring assemblies are rigidly mounted to the vertical shafts of the arms, and the arms are mounted so that they will slip if pressure becomes too great on the tray. This is accomplished by using a lugged locking collar and a notched collar (fig. 7) on each vertical shaft. When a lodged tray will not move, the spring absorbs the torsion, leaving the tray with only the pressure of the spring against it. The kickoff arms are made from 13½-inch-long, 1-inch-square tubing. They are located 15 inches to the left and right of the center of the hopper. Each arm is connected to its vertical 1-inch shaft by means of the 1-inch lugged locking collar mentioned above, which turns on the shaft.

OPERATION

After the hatchery tray passes by the sexers and all chicks are taken out, it is emptied and placed in the washer. In the past, this operation required two men working at a rapid pace to empty the trays into barrels and then place them in the washer. Two additional workers were required to transport and empty the barrels into a truck. The automatic tray

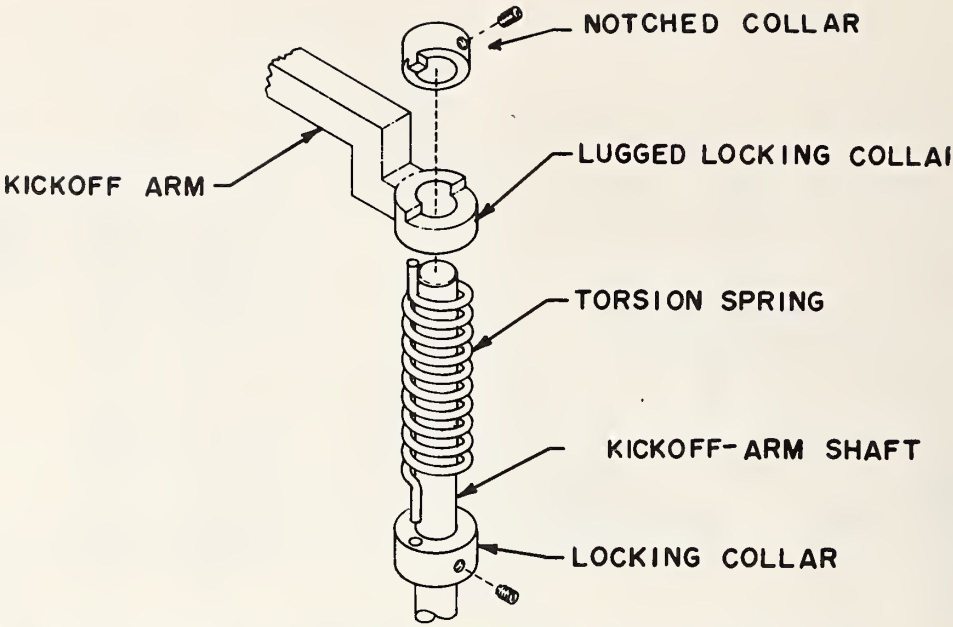

FIGURE 7.—Breakdown of spring-loaded kickoff arms for removal of trays from hopper.

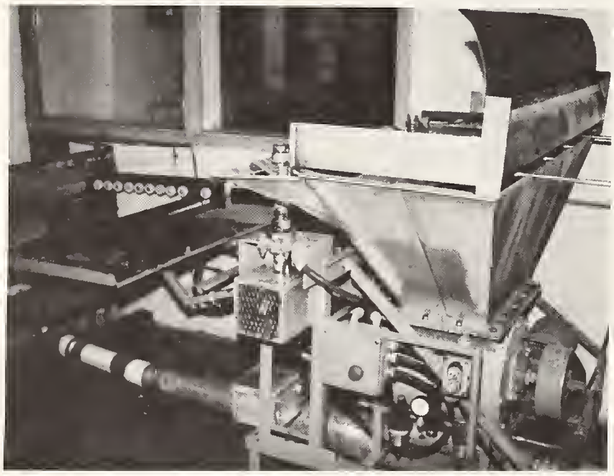

FIGURE 8.—Dumper assembly in correct position to accept tray.

dumper was designed and built to work in conjunction with a pneumatic transport system to eliminate or minimize these labor requirements. The automatic tray dumper is operated by two five-port, spring-return solenoid valves, two air cylinders, and a network of limit switches. The following description is a systematic breakdown of the dumper operation.

The hatchery tray is moved directly from the hatchery cart and placed on a roller conveyor that moves the tray past the sexers, who remove and segregate the birds. The tray strikes and thus energizes the ram limit switch (fig. 5), located at the end of the conveyor, which actuates the double-acting air-cylinder ram (fig. 6) which in turn pushes the tray sideways off the conveyor and toward the dumper platform (fig. 8). When the tray breaks contact with the ram limit switch, the air-cylinder ram retracts to accept another tray.

The trays progress forward until the first tray reaches, and slides onto, the lift platform, making contact with lift-platform (tray-table) limit switch LS 2, a plug-in, momentary-contact, spring-return switch (fig. 4, item 12; and fig. 5). When this limit switch is energized the NO contacts close, actuating a five-port, spring-return solenoid valve (fig. 6) which causes the lift-platform double-acting air cylinder (fig. 4, item 6; and fig. 6) to extend, raising the lift platform. Simultaneously, one set of the NC contacts of LS 2 actuates a time-delay relay (fig. 5). As the platform begins the ascent, cam-actuated limit switch LS 3 (fig. 4, item 15; and fig. 5), located on the pusher-arm shaft and wired in series with the other set of NC contacts, is energized to open the circuit to the ram solenoid, which will not allow the air-cylinder ram to push another tray forward during the dumping operation.

At this point the lift platform must traverse an arc of 100° to lift the tray to a point just past vertical in order to make the tray fall off the platform onto the hopper. An air pressure of 80 pounds per square inch gage was inadequate to start the lift

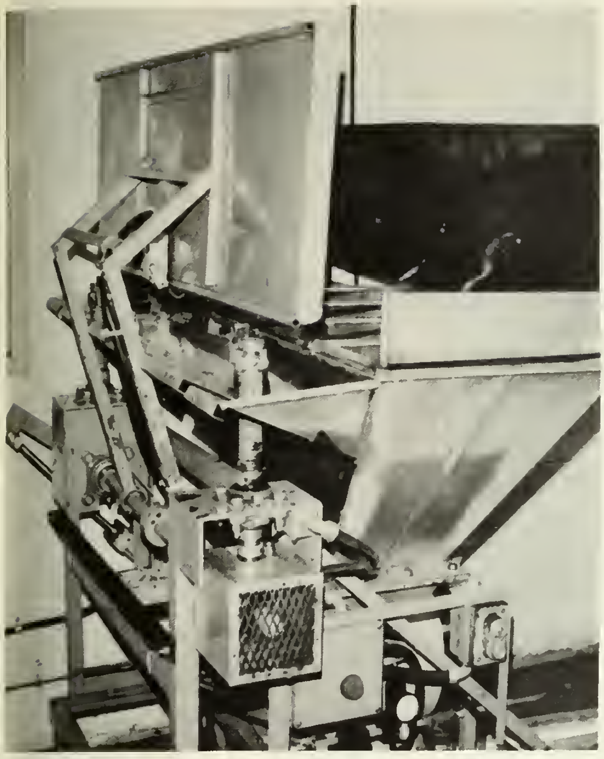

FIGURE 9.—Dumper assembly immediately after dumping tray onto hopper.

platform and full tray upward, so an adjustable compression-spring assembly (fig. 4, item 9) was added to assist in accomplishing this operation. The spring was adjusted to add enough lift to overcome the weight of the tray and platform and thus start the platform in motion. When the platform starts upward, the pressure of 80 pounds per square inch is more than enough to push it through a complete cycle. As the platform starts upward under maximum airflow, cam-actuated air switch LS 4 (fig. 4, item 14; and fig. 6) on the kickoff-arm shaft bypasses the airflow control valve in the "extend" exhaust port of the spring-return solenoid valve (fig. 4, item 11). This allows the platform to traverse the first 70° at maximum speed and then reduces the airflow for the final 30° to allow the tray to fall softly onto the hopper in an inverted position.

After the tray falls onto the hopper, the previously mentioned time-delay relay (fig. 5) continues to hold the platform in a vertical position for approximately 1½ seconds (fig. 9), which allows the tray to settle onto the hopper before the platform returns to the down position. When the tray breaks contact with LS 2 and the time-delay relay times out, LS 2 deenergizes the spring-return solenoid valve (fig. 4, item 11; and fig. 6) which retracts the double-acting air cylinder to bring the platform back to its starting position. On the downward movement of the platform, the kickoff arms push the tray off the hopper onto a conveyor leading to the washer. When the lift platform reaches the bottom, LS 3 closes the circuit to the ram solenoid, which starts the cycle over again.

EVALUATION

The automatic tray dumper was first tested in the lab, and a noise level of 100 dBA was measured on each cycle. A vibration dampening material was adhered to all major exterior surfaces of the hopper, and the level was reduced to 90 dBA. The noise produced is of an impact nature, occurring a maximum of 6 times per minute. Federal regulations on noise state that "if the variations in noise levels involve maxima at intervals of one second or less, it is to be considered continuous";[2] therefore, the level of 90 dBA is not considered continuous and is in compliance with these regulations.

The complete assembly was installed at a layer hatchery that hatched 125,000 eggs per day and was tested under normal commercial hatchery operating conditions for a period of 7 months with no major problems.

The waste-handling system is commercially feasible and practical. It reduces manual-labor requirements by more than 50 percent and makes cleaning up easier. Adoption of the complete system by industry could significantly reduce the cost of waste handling.

[2]General Industry Safety and Health Standards. Occupational Safety and Health Administration Publ. 2206 (29 CFR 1910), U.S. Department of Labor. Revised January 1976.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—771-106/18

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